CISH

Vision 2030

Central Institute for Subtropical Horticulture

Rehmankhera, Lucknow

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Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approaches based on cutting edge science. In this endeavour, all the institutions of ICAR have revised and prepared respective *'Vision 2030'* document highlighting the issues and strategies relevant for the next twenty years and programmes outlined accordingly.

Central Institute for Subtropical Horticulture, Lucknow is a premier institute under ICAR for subtropical fruit crops research with focus on mango, guava, aonla, bael, papaya and some underutilized fruits. It is the major centre for mango research in the country with conservation of the world's richest field genebank. The major emphasis is on the collection, evaluation, characterization, conservation and utilization of germplasm, crop improvement through conventional and biotechnological approaches for development of trait-specific varieties and production systems sustainable and lucrative. The institute through technological interventions and linkages and partnerships with national and international institutions aims to contribute to increase productivity, quality, exports and income of farmers engaged in cultivation of these crops.

It is expected that the analytical approach and forward looking concepts presented in the '***Vision 2030***' document will prove useful for researchers, policymakers and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(S. AYYAPPAN)

Dated the 8th July, 2011
New Delhi

Preface

The subtropical horticulture has been contributing to the food, nutritional security and livelihood of a vast majority of the farming community in the northern Indian plains for a long time. The scenario while presenting variety of opportunities also poses diverse challenges and constraints. The prevailing agro-climates and edaphic factors across this zone though limit culture of many horticultural crops with high outputs of quality has not deterred the zeal of horticulturists and entrepreneurs to embark upon diversification in this sector in order to augment sustainability and profitability. The horticulture of this kind needs to sustain and thrive in the emerging scenario of declining land, water and labour besides dynamics of weather parameters.

Central Institute for Subtropical Horticulture (CISH), Lucknow undertook elaborate exercise of revising the *CISH-Perspective Plan Vision-2025* through critical appraisal of the emerging scenario, stakeholders' consultation, RAC comments, perceptions of ICAR and in-house discussions. The institute, started initially as a Regional Station of Indian Institute of Horticultural Research, Bangalore in 1972, has grown into a full-fledged institute of international importance. CISH during its existence for over three decades has developed an array of varieties and suitable technologies for the mango and guava growers of India. The institute also locates the headquarters for the All India Coordinated Research Project on Subtropical Fruits being operated in 19 centers across the country. Many challenges and perspectives have been visualized since the institute presented the

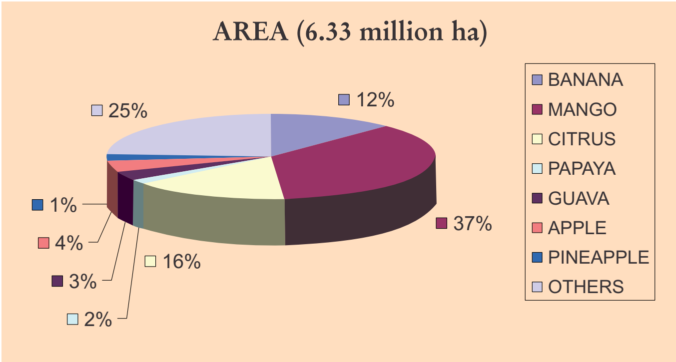
Vision 2025. We take great pride in presenting the '***Vision 2030***' of this institute that harmonizes multi-disciplinary team, problem solving approaches with focus on small farmers' issues, sustainability and profitability. The institute is concentrating on mango, guava, aonla, bael, papaya and some underutilized fruits and targets to strive towards integrated farming system. The Vision document has been prepared with the objective of developing a road map for obtaining high productivity of quality outputs of mandate crops including aspects of secondary agriculture. It is sincerely hoped that CISH in due course will emerge as the flagship institute especially for mango growers of the world in addition to other mandate crops which ICAR will feel proud of in years to come.

I would like to place on record my grateful appreciation to all my colleagues presently working at CISH and those who have retired from this institute after rendering meritorious service. Everyone at the institute has contributed inputs for preparation of this document. I would especially like to thank my fellow editors Drs A. K. Misra, D. K. Tandon, R. M. Khan, Ajay Verma, B. K. Pandey, R. P. Shukla, Shailendra Rajan and Heads of Divisions for facilitating to bring out this document in the abridged form. The encouragement and suggestions received from Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, Dr. H. P. Singh, Deputy Director General (Horticulture) and Dr. S. Rajan, Assistant Director General (Horticulture-I) from time to time are gratefully acknowledged.

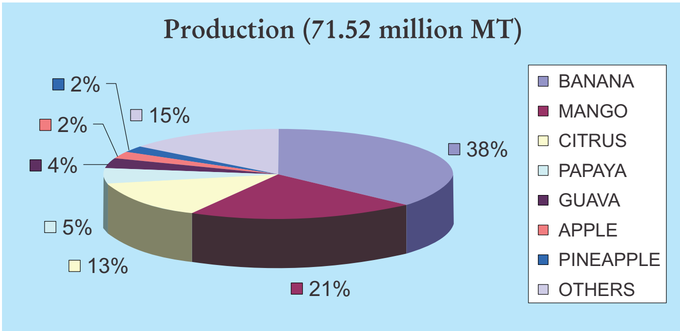
(H. Ravishankar)
Director

Preamble

The economic importance of horticultural produce has been increasing over the years due to increasing domestic and international demand. Area, production, productivity, availability and export have increased manifolds. This has provided ample opportunities for utilization of waste/marginal lands, employment generation and effective land use strategies. India is the second largest producer of fruits (71.52 million MT) obtained from 6.33 million ha area and contributing about 12 per cent share in global fruit production arising from 11.5 per cent area under horticultural crops. The horticulture sector contributes about 30.4 per cent of the agriculture GDP, besides providing employment for 19 per cent of the labour force. The demand for horticulture produce is expected to increase owing to increasing urbanization, income-lead higher standard of living, enhanced awareness of nutrition security and family welfare programmes. India occupies first place in the production of mango, banana, papaya, pomegranate, sapota and aonla. However, productivity in citrus, mango, apple, guava and pineapple continues to be lower than the world averages. The diversification through horticulture has proved the best option for the farmers to meet the need for food, nutrition, health care, besides providing better returns on farm land and employment. This sector has contributed significantly in generating employment opportunities, which has increased 7 folds. Resultantly, horticulture has been identified for inclusive growth of agriculture sector in the country. The research and development initiatives and policy support to tropical and subtropical fruits sector have greatly contributed to the overall growth of horticulture in the country.



Proportional area (%) of major fruit crops in India during 2009-10



Proportional production (%) of major fruits in India during 2009-10

The research and development programmes in horticulture have greatly contributed to the present scenario. Still there are a few gaps which need to be addressed for consolidation of strengths. Multi-location testing of varieties for adaptation, quality evaluation of clones and production of nucleus planting material of elite clones are necessary for providing fillip to the growth and sustenance of subtropical horticulture. Studies need to reorient towards identification of resilient varieties which can adapt to dynamics of weather parameters and thrive to produce satisfactorily under different kinds of biotic and abiotic stresses. Identifying resistance sources and evolving trait-specific, high yielding and disease resistant varieties through selection, mutation and polyploidy breeding by exploiting biotechnological tools are among the hallmark programmes. The recent advances in some frontier technologies such as satellite imagery availability, use of GPS and modern mapping techniques using GIS could greatly improve the understanding of the land use planning and these need to be exploited for expanding subtropical horticultural crops. Adoption of good horticultural practices and value chain concepts in production and utilization will open up new vistas in the prevailing scenario of demand for food and environmental safety as future markets are going to be highly quality conscious with stringent regulations.

Despite making substantial progress and opening up opportunities, some problems are continuing and remain unresolved. To mention a few of them are chiefly, alternate bearing, malformation, jelly seed formation, wilt and dieback in mango, guava wilt and regulation of cropping, papaya ring spot virus, quality standards of planting materials, optimize water and nutrient productivity, mechanization of operations, value addition, product diversification, food and environment safety, waste utilization, etc. All these require due focus in future programmes.

Considerable efforts are needed to harmonize and integrate pre-harvest protocols for ensuring efficient post-harvest management system including value addition. Supply chain management, storage and cold chain are crucial to reduce losses in the post-harvest stage. Market intelligence, creation of alternate markets and integration of farmers are crucial. Rapid expansion of mobile telephone technology and its affordable access even in rural areas should be exploited gainfully to the stakeholders issues on different aspects of production, utilization, and market access.

The issues of thrust that could be flagged include: effective management and evaluation of genetic resources and development of improved cultivars with high quality characteristics, productivity, resistance to biotic and abiotic stresses; quality seeds and planting materials; efficient utilization of power of micro-organisms; develop system for use of each drop of water for increasing production; increasing nutrient use efficiency; develop alternatives to chemicals and fertilizers; judicious use of chemicals for the control of pests and diseases; development of organic production systems; recycling and waste utilization; conservation of biodiversity; modernization of production and post-harvest technologies; development of diagnostic techniques for rapid, accurate and cost effective detection of pests and diseases; mechanization for enhancing the efficiency of horticulture production systems; adoption of improved technologies for bio-security threats; and impact analysis of technologies.

The '***Vision 2030***' document envisages harmony with the objectives set out by the Indian Council of Agricultural Research, New Delhi for promotion of sustainable agriculture in the country. Thrusts have been given on research in frontier areas of science, horticulture for small farmers, secondary agriculture, etc., so as to realize the set goals of rendering subtropical horticulture not only sustainable but also profitable leading to inclusive growth of horticulture sector.

Contents

1. Scenario

India is the second largest producer of fruit crops in the world after Brazil. The total area under fruits in the country is reported as 6.33 million ha during 2009-10 with a production of 71.52 million MT. Mango is the most important fruit crop of the country, as it occupies maximum area, i.e., 2.31 million ha accounting for about 37 per cent of the total area under fruits. However, in terms of production (15.03 million MT), it ranked second after banana (27.1 million MT) during 2009-10. Andhra Pradesh has reemerged as the leading state in terms of area allocation as well as production of mango in the country. During 2009-10, it produced 4.06 million MT of mangoes from an area of 0.48 million ha, accounting for 20.8 per cent of the area and 27 per cent of the total production in the country. Uttar Pradesh ranked third with 0.28 million ha area and production of 3.59 million MT, i.e., 12.0 and 23.9 per cent area and production in the country, respectively. Although area under mango in Maharashtra is 0.47 million ha (20.5%), and it is second largest mango growing state, it produced only 0.60 million MT of mango accounting for a meager 4.0 per cent of total mango production in the country. Karnataka is another important state for mangoes with a share of 11.3 per cent of the total mangoes produced in the country. The productivity of mango is the highest, i.e., 13.0 MT per ha in Uttar Pradesh as against only 11.10 and 8.4 MT per ha in Karnataka and Andhra Pradesh, respectively. In all the other states, the productivity was less than 7 MT per ha. Maharashtra, which is known for mango cultivar Alphonso, recorded productivity of only 1.3 MT per ha, which is minimum in the country. The average productivity in all the states taken together is only 6.5 MT per ha.

Guava, another important fruit crop of subtropics, was cultivated in 0.22 million ha with a production of 2.57 million MT during 2009-10.

Its area and production was 3.5 and 3.6 per cent, respectively. Uttar Pradesh is the most important guava producing state with an area of 0.04 million ha, accounting for 18.2 per cent of the total area under it in the country. Maharashtra, Madhya Pradesh, Bihar and West Bengal are the other important guava growing states. The productivity of guava is highest, i.e., 29 MT per ha in Madhya Pradesh followed by Punjab, Karnataka, Gujarat, Andhra Pradesh, West Bengal and Uttar Pradesh with a productivity of 21.2, 19.3, 15.9, 15.0, 13.1 and 12.2 MT per ha, respectively. The state of Uttar Pradesh, which is known for famous cultivar Allahabad Safeda, has lot of scope to enhance its productivity, provided improved cultivation practices are adopted.

The area under papaya cultivation in the country was only 0.10 million ha producing 3.91 million MT during 2009-10. Its share is only 1.5 and 5.5 per cent of total area and production in the country, respectively. Andhra Pradesh and Gujarat are the major papaya producing states. The area under papaya in these states was 0.019 and 0.015 million ha accounting for 19.6 and 16.0 per cent of the total area under the crop in the country, respectively. Corresponding production in the states was 1.5 and 0.8 million MT, respectively, contributing 38.3 and 21.3 per cent of the total papaya production. Karnataka and West Bengal are the other important states accounting for 10.7 and 8.2 per cent of the total papaya production, respectively. Tamil Nadu reported highest productivity of 180.2 MT per ha followed by 115.6 MT per ha in Madhya Pradesh. Andhra Pradesh, Gujarat and Karnataka reported the productivity of 80.0, 54.3 and 72.3 MT per ha, respectively. The productivity of papaya in other states was below 30 MT per ha. The average productivity of papaya in the country is 40.9 MT per ha.

The productivity of major fruits in India during 2009-10 is depicted in Fig. 1 and growth in productivity of mango, guava and papaya is shown in Fig.2.

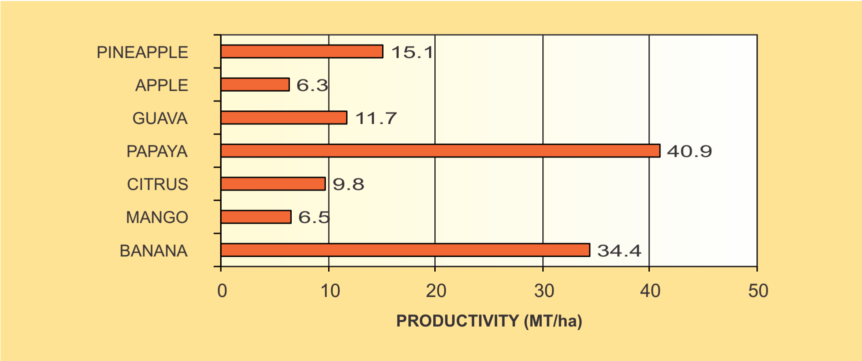


Fig. 1: Productivity of major fruits in India during 2009-10

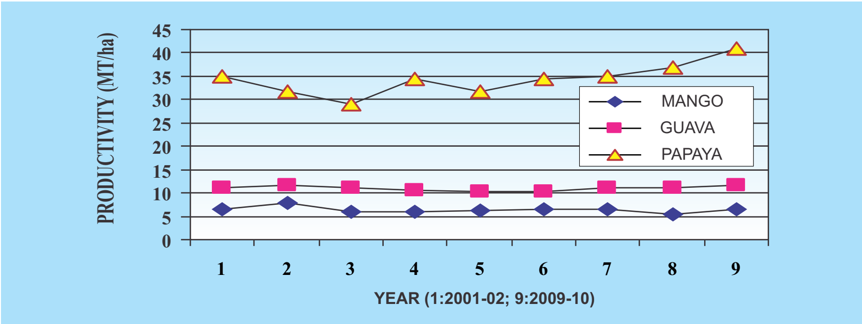


Fig. 2: Growth in productivity of mango, guava and papaya

Aonla is a crop which is valued very high among the indigenous medicinal systems. It can be planted even in the salt affected soils including ravines, particularly in the states of Uttar Pradesh and Madhya Pradesh. Now its cultivation has spread in semi-arid regions and Aravali region too. The cultivation of aonla has spread over in more than 50,000 ha with a production of 1.5 lakh tonnes. Major aonla growing states are Uttar Pradesh, Gujarat, Tamil Nadu and Rajasthan.

Bael is another fruit crop which has high medicinal value. There is no organized orcharding of bael as it is grown on the bunds of field or waste land. The main growing states in the country are Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, West Bengal, Orissa, Chattisgarh and Rajasthan.

Some underutilized fruits like jamun, chironjee, phalsa, karonda, etc., are gaining importance due to their medicinal and therapeutic values and other uses. The information about their area and production are not available authentically and CISH has initiated research work on these fruits and started maintaining their diversity in field gene bank.

Compound growth rates in area, production and productivity

A perusal of compound annual growth rates of area production and productivity of the mandate fruit crops indicated that the area under mango increased by 5.72 per cent per annum during five year of Period-I (2001-06), thereafter it declined to 1.79 per cent per annum during Period-II (2006--10) (Table 1). The total production of mango increased by 4.79 per cent per annum during the Period-I and declined to 2.27 per cent per annum during the Period-II. The productivity of mango showed a negative growth of 0.96 per cent during the Period-I, after which it showed a marginal recovery of 0.39 per cent per annum during Period-II.

Growth in area under guava during the Period-I was marginal at 1.49 per cent per annum, which attained a significant growth of 5.70 per cent per annum in the Period-II. The increase in production of guava during the same periods was 0.24 and 8.86 per cent per annum, respectively. The productivity of guava during the Period-I depicted a negative growth of 1.29 per cent per annum, which recovered to 2.99 per cent per annum in the Period-II.

Table 1: Compound growth rates in area, production and productivity of mango, guava and papaya

Parameter	Period	Year	Mango	Guava	Papaya
Area (%)	Period-I	2001-06	5.72	1.49	-1.56
	Period-II	2006-10	1.79	5.70	7.37
	Over All	2001-10	4.31	3.49	2.92
Production (%)	Period-I	2001-06	4.79	0.24	-3.75
	Period-II	2006-10	2.27	8.86	12.08
	Over All	2001-10	4.56	4.55	4.65
Productivity (%)	Period-I	2001-06	-0.96	-1.29	-2.08
	Period-II	2006-10	0.39	2.29	4.35
	Over All	2001-10	0.17	0.58	1.70

A negative growth rate of 1.56 and 3.75 per cent per annum was observed in area and production of papaya, respectively, during the Period-I. It, however, registered an impressive increase of 7.37 and 12.08 per cent per annum in area and production, respectively, during Period-II. Consequently, the growth in productivity of papaya during the first period was negative at 2.08 per cent per annum. It registered an increase of 4.35 per cent per annum during the Period-II.

Constraints in achieving the targeted growth rates

- Inadequate supply of genuine quality planting material.
- About 40 per cent of mango plantations in India are more than 40 years of age. They have become overcrowded and unproductive, thus, reducing the productivity drastically and have become uneconomical.
- Several biotic and abiotic factors cause substantial loss in the field and diseases at post-harvest stage cause huge losses during storage and transport.
- The new scientific practices of fruit cultivation are not fully adopted by the orchardists, thus, affecting the productivity and quality of fruits.
- Spurious plant protection chemicals, which are not effective, are being used extensively.
- Suitable CFB packages are not much in use.
- Existing transportation system for fruit crops is not suitable for long distance transportation.
- Non-availability of cultivars having longer shelf life.
- The practice of giving orchards to pre-harvest contractors has been found to lead to poor orchard management, resulting into poor quality of fruits.
- Marketing channel of mango and other fruit crops is too long resulting into low income to the growers.

- Efficient supply chain management in fruit crops is lacking.
- Majority of the plantations of guava are still seed propagated with low productivity and quality.
- Guava wilt continues to be a serious problem resulting into wiping of many orchards.
- Non-availability of frost-free varieties of papaya, especially for the northern region.
- Non-availability of varieties immune to Papaya Ring Spot Virus (PRSV) and Papaya Leaf Curl Virus (PaLcv). The infection of crop with PRSV and PaLcv has virtually restricted its planting in the northern region.

Demand and supply projections

The demand projections (year 2030) for fruits are estimated at 122.12 million MT (Table 2). Similarly, the production of fruits was projected as 220.57 million MT. This production is sufficient to fulfill the projected demands for fruits. Since, there is not much scope for area expansion, the productivity enhancement is envisaged through adoption of good management practices including techniques of high density planting, rejuvenation of old and unproductive orchards, top-working, window opening, INM, IPM and improved post-harvest handling and management systems for reducing post-harvest losses. In mango, wherever rejuvenation is not feasible and economical, replacement of the old and unproductive orchards could be taken-up with high density planting. The projected production for mango is 36.92 million MT in the year 2030. The efforts would require adequate public and private investments in the mango industry.

Table 2 : Projections for fresh fruits by 2030

Parameter	Current 2009-10	Projected 2030
A. Demand		
Population (million)	1150.00	1530.00
Dietary demand for fresh fruits (million MT)	41.98	55.85
Post-harvest losses (million MT)	17.88	39.76
Export demand (million MT)	0.14	4.42
Requirement for processing (million MT)	1.79	22.09
Total (million MT)	**61.79**	**122.12**
B. Supply (million MT)	**71.52**	**220.57**

Assumptions

- The post-harvest losses will be brought down from 25 to 18 per cent by 2030.
- The export demand will increase from 0.2 to 2 per cent by 2030.
- The demand for processing will increase from 2.5 to 10 per cent by 2030.

Export and import performance

Mango

a) *Export*

India has been a traditional exporter of mango and its products. It exported 74.46 thousand MT of mangoes worth Rs. 200.54 crore to 55 countries during 2009-10 (Fig. 3). Bangladesh alone imported 33.55 thousand MT of mangoes accounting for 45 per cent of the total exports from India. Although United Arab Emirates imported only 25.61 thousand MT with a share of 34 per cent in total Indian mango exports, its value was Rs. 103.83 crore accounting for 52 per cent of the total value of mango exports from India, positioning it as the most important destination (Fig. 4). Saudi Arabia, Kuwait and United Kingdom were the other important markets for Indian mangoes. The country exported 236.34 thousand MT of all mango products worth Rs. 1013.62 crore during the year 2009-10. It exported 186.2 thousand MT of pulp worth Rs. 744.61 crore to different destinations (Fig. 4). It alone accounted for about 78.8 per cent of the total mango product exports to different destinations in terms of quantity and 73.5 per cent in terms of value. Saudi Arabia and UAE continued to be the dependable importers of pulp from India by receiving 63.48 and 17.05 thousand MT of the product, respectively. Therefore, their share in the total mango pulp exports from India were 34 and 9 per cent, respectively. Besides, Kuwait and Yemen Republic continued to be major importers of mango pulp from India. The Netherlands is fast emerging as the major mango pulp importer from India. The export of pulp was followed by export of 44,900 MT of jam, worth Rs. 245.89 crore, during the year. Squash, slice (dried), slice (brine)

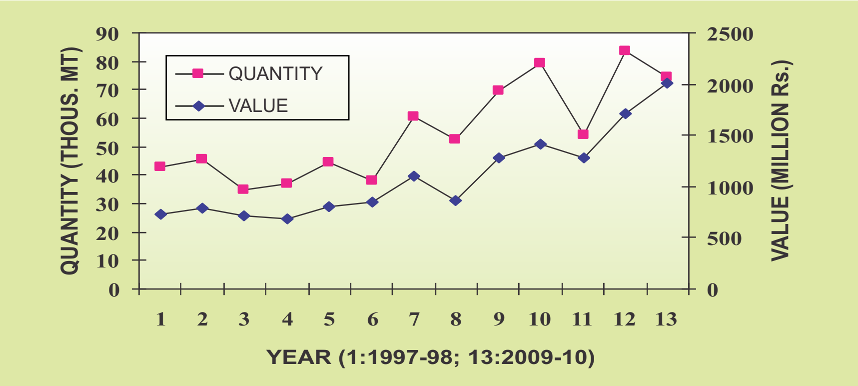


Fig. 3 : Growth in export of mango from India

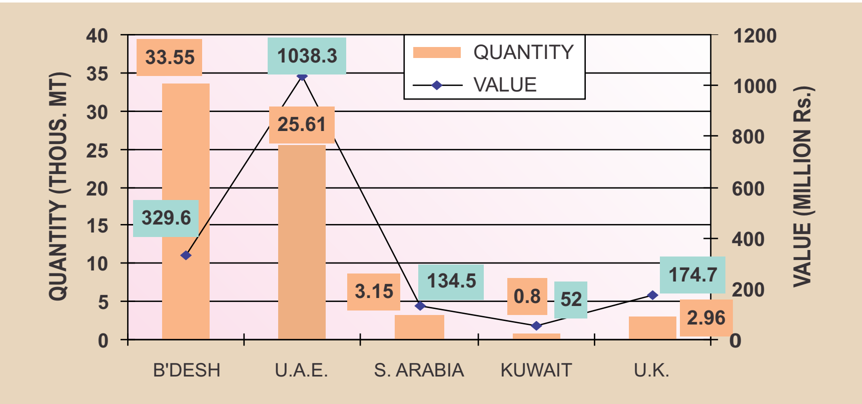


Fig. 4: Export of mango from India to major countries during 2009-10

and juice were the other important mango products exported from the country.

Constraints

- Each importing developed nation requires different pre-treatment of mango, e.g., USA needs irradiated fruits, while Japan's requirement is VHT. These process infrastructures, besides not being available at all the places, are expensive, thereby increasing the cost of exports and placing the country in a disadvantageous position.
- Concerted efforts are not being made to implement the CODEX *Alimentarius* and GLOBALGAP standards in India. These standards are essential for export of mango to the European Union and USA, besides accommodating their own standards on quarantine, etc.

b) *Import*

During the year 2009-10, India imported 0.36 MT of mangoes worth Rs. 33 lakh from Pakistan. It also imported 2.6 thousand MT of juice worth Rs. 6.86 crore from 14 countries. Bangladesh emerged as the single largest exporter of juice to India by accounting for 88 per cent of the total juice imports by India. Pulp and squash are the other mango products which were imported. Jam was mainly sourced from The Netherlands and U.K, but its quantity was meager, i.e., 9.66 MT worth Rs. 11.96 lakh.

Guava

India exported only 0.52 thousand MT of guava fruits worth Rs. 11.34 crore during 2009-10. Oman and Nepal accounted for 15 and 12 per cent, respectively, of the total guava exports from India. The price realization of guava in Nepal was low *vis-à-vis* other major importers. Jelly and RTS beverages were the two major products of guava exported from India. A total of 5.56 thousand MT of guava products worth Rs. 158 crore was exported to different countries. Jelly was the single largest item as it accounted for about 98 per cent of the exports and 97 per cent of the total value of the guava product. The Netherlands, U.K. and Saudi Arabia accounted for 22, 13 and 12 per cent of jelly exports from India, respectively.

Papaya

India exported 17.92 thousand MT of papaya worth Rs. 17.49 crores during the year 2009-10. United Arab Emirates, the single largest importer, imported 7.65 thousand MT of fruits worth Rs. 7.3 crore, thus, accounting for 43 and 42 per cent of total quantity and value of papaya exports from India, respectively. Saudi Arabia, The Netherlands and Bahrain were the other major destinations for Indian papayas accounting for 18, 10, and 8 per cent of the value of papaya exports, respectively.

Climate changes and productivity

The climate change appeared to have impacted environmental factors influencing crop phenology aspects, *viz*. flower bud differentiation, intensity of flowering, maturity period, fruit yield along with quality, physiological disorders and pests and diseases incidence, that could render either decimation of traditional areas or ensure additional areas becoming feasible for production of these crops. Consequent upon shifts in weather patterns, fruit-bud differentiation and early and delayed flowering are likely to be the characteristic features of mango production in future. Early flowering would affect low fruit-set not only because of low night temperatures, but also due to lower temperatures during day that would negatively impact pollinator's activity resulting in low fruit set. Conversely, late flowering in conjunction with high temperature fluxes results in reduced fruit-set arising due to 'clustering' (nubbin fruit formation) i.e., pseudo-setting phenomenon. Prevalence of high temperatures during panicle development leads to quick growth, resulting in reduced number of days for effective pollination, and eventually poor fruit-set. Further, it would also cause desiccation of pollen and poor pollinator activities leading to low fruit-set. In north India, delayed maturity (one week) in cultivar Dashehari and unusual pattern of rains during development stages result in low quality mangoes having poor market appeal. It was observed in the

Konkan region of Maharastra during 2009-10 that lack of early rains and abrupt rise in temperature by 8°C on a single day at harvest resulted into rotting of fruits on the trees leading to extensive losses to Alphonso mango production, while prolonged prevalence of low temperatures below 17°C for more than 62 days during 2010-11 affected crop outputs.

Weather aberrations also affect production and quality of guava significantly. Summer rains during pre-monsoon periods, particularly in areas where winter crop is taken as a major crop, affect the phenology resulting into early end of winter crop. Prevalence of high summer temperatures in the previous year suppresses the blossom bud differentiation and promotion of extension growth in major parts of guava growing regions. Attractive red coloured guava varieties develop anthocyanin in the fruit peel at low temperatures during cool nights at fruit maturation stage. An analysis of weather data showed that areas with minimum temperature of 8-10°C or even cooler nights during winters are more suitable for the quality production, while rise in winter temperatures during nights result in poor red colour development. Even varieties without red colour on the peel developed better fruit qualities during cooler nights. So far as insect-pests infestations are concerned, early winter crop is attacked by insect-pests, especially fruit flies and borers. Anthracnose disease of guava in rainy season crop is greatly influenced by number and frequency of rainy days.

Production of papaya in terms of quantity and quality is also invariably affected by weather upheavals. Extremes of low temperatures during winter result in burning of leaves followed by anthracnose infection on fruits, which adversely affect the fruit quality. Papaya is also highly sensitive to frost, which adversely affects the papaya production. High temperatures during summer affect pollen fertility causing reduction in fruit setting and sex reversal.

2. About CISH

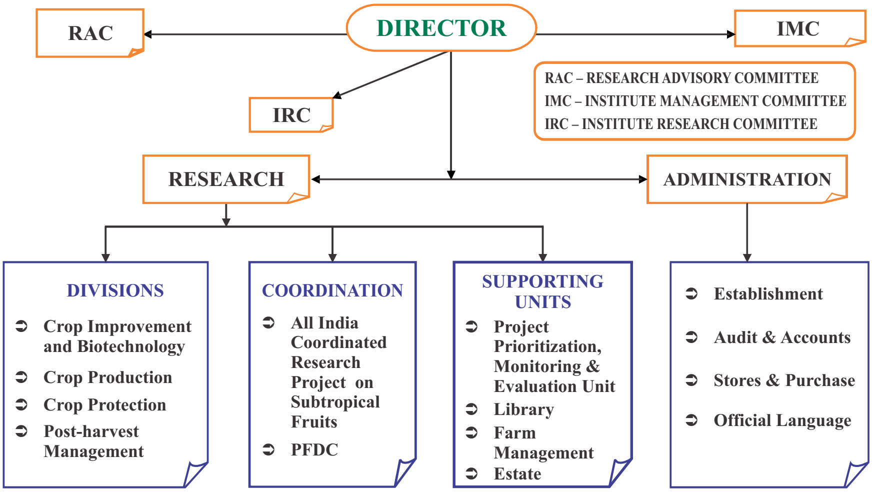
Chronology

Central Mango Research Station was started on September 4, 1972 as a Regional Station under the aegis of Indian Institute of Horticultural Research, Bangalore. It was upgraded to a full-fledged institute and named as Central Institute of Horticulture for Northern Plains on June 1, 1984, which was later renamed as Central Institute for Subtropical Horticulture (CISH) on June 14, 1995. The institute is serving the Nation on different research and developmental aspects on mandated subtropical fruit crops.

Location and infrastructure

The institute has two experimental farms, one located at Rehmankhera, approximately 25 km away from the city and the other at Rae Bareli (R.B.) Road, right in the city of Lucknow. The experimental farm at Rehmankhera has a total area of 132.5 ha comprising of four blocks (block I-15.5 ha, block II-35.5 ha, block III-37.42 ha and block IV-44.08 ha), while R.B. Road campus has 13.2 ha. area. To meet the emerging challenges in the frontier areas of research on subtropical fruits, the institute has set up modern scientific nursery at block I and well established orchards and fully equipped laboratories and a good library at block II of Rehmankhera farm. Residencial complex, guest house, biocontrol lab and technology demonstration farm are located at RB Road campus. Location of Rehmankhera farm stands at 26° 45' to 27° 10' N latitude, 80° 30' to 80° 55' E longitude and 123 m above the sea level. The institute has total sanctioned strength of 172 staff, comprising 47 scientific, 57 technical, 24 administrative and 44 supporting with the total budget allocation of approximately 73.75 crore during the XIth plan.

Organogram



Organizational set-up

The institute's functioning is organized through four divisions, *viz.* Crop Improvement and Biotechnology, Crop Production, Crop Protection and Post-harvest Management. It houses the headquarters of All India Coordinated Research Project on Subtropical Fruits, facilitating its activities. The institute also has Precision Farming Development Centre for promoting high-tech horticulture.

Mandate

- Undertake basic and strategic research to enhance productivity and develop value chain in major and minor subtropical fruits.
- Act as national repository of above fruit crops.
- Act as a centre for human resource development and provide consultancy to the stakeholders.
- Develop linkages with national and international agencies to accomplish the above mandates.

Objectives

- Management of genetic resources of mandate fruit crops and their conventional and molecular characterization.
- Crop improvement through breeding and genetic engineering.
- Enhancing productivity through improving quality and quantity of planting materials using modern propagation techniques and rootstocks, precision farming practices including mechanization and management of biotic and abiotic stresses.
- Reduction in post-harvest losses through improved pre-and post-harvest management practices, value addition and diversification of products.
- Human resource development, transfer of technology and evaluation of its socio-economic impacts.
- Data storage and retrieval on all aspects of mandate fruit crops.

Varieties/Selections released by the institute

Ambika

Arunika

Lalit

Shweta

CISH-B-1

CISH-B-2

CISH J-37

CISH J-42

Approaches

Production of quality planting materials

Quality planting materials are the first and foremost requirement for successful fruit production venture. The production in mandate fruit crops is hampered by non-availability of quality planting materials in large numbers. Institute has developed state of art facilities for the production of quality planting materials in mango, guava, aonla and bael. Protocols have also been standardized for micro-propagation of bael and aonla. Institute has been offering scientific expertise and core planting materials to government agencies as well as private growers for establishment of mother blocks in different regions.

Nursery of the institute

Productivity enhancement technologies and systems

- Extensive/intensive surveys for collection, identification and subsequent conservation of superior cultivars.

- Introduction of exotic germplasm and their utilization in breeding programmes for development of varieties with target traits including colour, off-season fruiting, regular bearing, extended shelf life, etc.
- Identifying off-season mango varieties for extending the mango availability period.
- Development of genetic linkage maps for fruit colour, tolerance to biotic and abiotic stresses, etc., for reducing time required for breeding of desirable types in mango.
- Rejuvenation of mango orchards in relation to canopy architecture management, bearing behaviour, use of intercrops and mulching for improving productivity.
- Standardization of high density plantation in mango on the basis of light infiltration, photosynthetic efficiency, stomatal behaviour and harnessing solar energy, etc., by modifying tree canopy architecture.
- Development of techniques for enhancing the value of composts through incorporation of organic wastes, rock phosphate, dolomite, lime, oil cakes, bio-fertilizers, fish meal, etc.
- Development of techniques for balanced and conjunctive use of different sources of nutrient supply including bio-fertilizers for evolving integrated plant nutrient management (IPNM) modules in local/regional perspectives.
- Management of irregular bearing in mango cvs Dashehari, Chausa and Langra by application of paclobutrazol along with judicious inorganic/organic nutrient management, pruning and mulching.
- Unravelling the mechanism of drought and salt tolerance.
- Development of rootstock(s) in mango for dwarfing and tolerance to problematic soils.
- Study of root physiology in relation to nutrient dynamics and carbon transport and partitioning for understanding bearing behaviour in mango.
- Integrated approaches for management of mango malformation.

- Identification of nutrient related constraints on bench mark soils in mango growing regions of northern plains.
- Optimization of irrigation water requirement with micro-irrigation including fertigation.
- Development of pink pulp coloured varieties of guava combined with less and/or small soft seeds, better quality, good shelf life and suitable for high density cultivation.
- Development of guava varieties with high vitamin C, lycopene, carotenoids and antioxidant contents.
- Meadow orcharding in guava and standardization of package of practices for high density planting of guava by modifying tree canopies for increased production efficiency.
- Screening of papaya germplasm against viruses and development of stable hermaphrodite types.
- Collection, conservation and evaluation of superior germplasm of aonla, bael and litchi suitable for the region.
- Collection and evaluation of indigenous and exotic germplasm of underutilized fruits, *viz*. jamun, mahua, chironji, karonda, khirnee, woodapple, tamarind, amra, badhal, custard apple, loquat, lasoda, mulberry, phalsa, carambola, etc.

Pests and diseases management

- Collection and conservation of strains of pathogens (fungal, bacterial and viral) of mango, guava and papaya and their characterization by traditional and modern methods, particularly by molecular tools.
- Survey, surveillance and identification of newer diseases of subtropical and underutilized fruits.
- Etiology, ecology, epidemiology and histopathology of important diseases of subtropical fruits.
- Identification of resistant source(s) against powdery mildew, anthracnose, bacterial canker, malformation, etc., in mango, wilt in guava and viruses in papaya.

- Management of pests and diseases of mango, guava, aonla, bael, etc., with newer molecules, biological control systems and eco-friendly approaches.
- Collection and identification of antagonists and their evaluation against powdery mildew, anthracnose, die back, bacterial canker, etc., in mango and wilt in guava.
- Identification of endophytic antagonistic bacteria, fungi and entomopathogenic nematodes for their exploitation in management of major insect pests and plant parasitic nematodes.
- Evaluation of different antagonistic organisms for their PGPR activity.

Post-harvest management, value addition and secondary agriculture

- Systems approach in mechanization of different orchard operations in mango, guava and other mandate fruit crops.
- Design and development of harvesting, destoning, pricking and shredding machines for aonla processing.
- Establishing safe waiting periods for different pesticides in subtropical fruits.
- Development of post-harvest protocols for long distance transport and export.
- Optimizing ripening protocols for commercial cultivars of mango and other fruits.
- Shelf life improvement through MAP and CA storage.
- Blending of fruit pulp for higher nutritional value.
- Development of technology for spray and freeze drying of fruit products.
- Development of health drinks/functional foods from subtropical fruits with special reference to their nutraceutical value.
- Preparation of fermented products like cider and wine from subtropical fruits.
- By-product development from processing waste.

Transfer of technology

- Development of export response models of mango and alternate markets, integration.
- Dissemination of technologies developed by the institute through proactive and exhaustive ICT modules, field demonstrations, *gosthies* and farmers trainings.
- Development of database on production of subtropical fruit crops.
- Development of effective technology dissemination modules and media resource avenues.
- Impact assessment of technologies developed by the institute.

Inter institutional collaboration

The institute has in place MOUs to facilitate capacity building initiatives with Integral University, Lucknow; Sam Higginbotham Institute of Agriculture, Technology and Science, Allahabad; APS University, Rewa; Babasaheb Bhimrao Ambedkar University, Lucknow; Bundelkhand University, Jhansi and Lucknow University, Lucknow for pursuing research as part of M. Sc. and Ph. D. degrees of their students. Institute is also recognized by IGNOU, New Delhi as one of the study centers for offering one year Diploma course on value added products from fruits and vegetables and a Certificate course on organic farming. National Horticulture Mission and National Horticulture Board (NHB), GOI have identified the institute as nodal centre for imparting training on rejuvenation of old and unproductive mango orchards and meadow orcharding in guava.

3. CISH Vision 2030

Vision

Augment the share of agriculture sector in general and horticulture in particular in the GDP of the country and its export basket.

Mission

Conduct basic and strategic research to develop cost effective and viable technologies for production of subtropical fruit culture as a component of integrated farming strategy.

Goals

- Conservation of genetic diversity of subtropical fruit crops for future utilization.
- Augment production, productivity, sustainability and competitiveness of subtropical fruit culture.

Focus

- Management of genetic resources of mandate fruit crops and their characterization through conventional and molecular approaches.
- Crop improvement through conventional breeding and genetic engineering.
- Enhancing productivity through improving quality and quantity of planting materials using modern propagation techniques and rootstocks, precision farming practices including mechanization and management of biotic and abiotic stresses.
- Reduction in post-harvest losses through integrated pre-and post-harvest management practices, value addition and diversification of products.
- Human resource development, transfer of technology and evaluation of socio-economic impacts.
- Data storage and retrieval on all aspects of mandated fruit crops.

4. Harnessing Science

Central Institute for Subtropical Horticulture, since inception with specific assigned tasks has been in the forefront accomplishing impressive marks in the research and technology development scenario at national and international levels. Planned strategies and visionary approaches involving crop improvement, production, plant health and post-harvest management systems of mandate crops utilizing proven conventional and contemporary frontier research areas for addressing the emerging problems have yielded valuable results.

Mission mode planned explorations for collection of invaluable germplasm, their characterization, documentation and conservation and eventual utilization for trait specific variety development programmes through conventional breeding has led to the development of two mango varieties 'Ambika' and 'Arunika' and two guava varieties 'Lalit' and 'Shweta' suitable for processing and global fresh fruit niche markets.

The institute has a rich assemblage of 732 mango accessions, which are being utilized for evolving varieties endowed with traits like regular bearing, malformation resistance and extended fruiting behavior. Besides, it also has 114 accessions of guava and 7 *Psidium* spp., 32 accessions of papaya, 54 accessions of bael, 35 accessions of aonla, 35 accessions of litchi and 218 accessions of underutilized fruits like jamun, khirni, karonda, tamarind, etc., in the field gene bank. Biotechnological tools are also being adopted for molecular characterization of germplasm of mango and guava. Efforts are also underway to develop transgenic plants of papaya conferred with dual resistance against Papaya Ring Spot Virus (PRSV) and Papaya Leaf Curl Virus (PaLcv). In view of locating newer varieties suitable for different agro-climatic regions of the country having mango/guava cultivation pockets, Geographical Information System (GIS) tools are being made use of. Consequently, the institute has been able to locate newer geographical sites suitable for cultivation of

Lalit, a pink pulped variety of guava evolved through selection. Lalit has covered substantial areas in the western and southern regions especially Maharashtra and Andhra Pradesh and performing well.

In view of the depleting water resources and ground-water contamination, precision farming techniques through available tools would be utilized for conserving and optimizing resource use. Developed drip irrigation/fertigation tools would help in conserving the scarce resources by checking their over- use/misuse. It would eventually lead to obtain higher yields sustainably and better quality harmonizing optimum resource use coupled with minimal risks of ground water contamination and environmental pollution.

Realizing the on-going global warming and its impact on flowering, fruiting behaviour and pests and diseases dynamics of mango has been taken into account and approaches to mitigate the adverse effects are being worked upon. The data gathered will be advantageously exploited through utilization of frontier science for predicting the climatic aberrations linked to crop production/ productivity, forecasting systems, integrated pests and diseases management system and diagnostics tools. Biotic factors linked risks, especially in view of climatic aberrations, would be managed through tools of forecasting models evolved, validated and expert systems developed to empower the orchardists for decision making.

Institute has also standardized and perfected rapid plant propagation protocols involving fine tuning of conventional procedures supported by modern facilities including net/green house, poly-house, etc. for round the year production of quality and genuine planting materials.

Secondary agriculture has assumed greater significance following the emergence of free market economy on global scale, quality conscious domestic as well as global clientele. Additionally, initiatives for rendering horticulture sustainable, profitable and viable with entrepreneurial orientation also underscores value addition for availing access to niche markets. Institute over the years has developed different products from mango, guava, aonla and bael, which have caught the imagination of a wide array of consumers. In the coming years too, the institute would continue to strive for development of variety of processed and novel value added products to make the cultivation and processing of mango, guava, papaya, aonla and bael highly remunerative and lucrative proposition. The protocols for export/long distance transport of mangoes using integrated pre-and post-harvest management practices have been developed. It was possible by implementing the above protocols to export mangoes to Gulf countries by road/sea transport through reefer containers during 2010 season which would be further consolidated. The recent technology development in the fields of improved methods of fresh fruit storage, handling and transport, food safety, high pressure processing, minimally processed products and waste utilization would also be incorporated.

5. Strategy and Framework

Genetic enhancement

Mango

- Development of varieties having features of regular bearing, dwarf stature, red peel colour, high yield, suitable for long term storage and processing.
- Development and standardization of rootstocks for dwarfing and abiotic stress tolerance.
- Breeding for malformation resistance.

Guava

- Development of varieties with red peel colour, pink pulp and soft and less seeds.
- Introgression of wilt resistance from wild relatives of *Psidium guajava* and integrated approaches for management of guava wilt.

Papaya

- Identification of papaya seedling for sex at juvenile stage using sex specific SCAR markers.
- Development of transgenics in papaya conferring resistance against PRSV and PaLcv.

Bael

- Selection of promising bael genotypes specially suitable for pharmaceutical and processing industries.

Aonla

- Introgression of genes of high vitamin C and polyphenols from the genetic diversity available into high yield background.

Jamun

- Identification of small and large seeded elite types with higher nutraceutical and medicinal values along with good shelf life.

Synergies of frontier science – biotechnology, nanotechnology, GIS

- Molecular profiling of important cultivars, varieties and hybrids along with gene sequencing.
- Marker aided selection for the desired traits and identifying genes controlling superior quality traits and resistance to pests and diseases.
- GIS based fruit resource and cultivar specific maps for specific agro-ecological situations and land use planning *vis-à-vis* climate change.
- Characterization and profiling of rhizosphere microbial community structure in the rhizosphere and non-rhizosphere environments.
- Assessing the ratio of slow and fast mobile nutrients at different developmental stages of leaves and to elucidate their relationship with flowering in mango.
- Isotope discrimination of carbon ($^{13}C/^{12}C$), oxygen ($^{18}O/^{16}O$) and nitrogen ($^{15}N/^{14}N$) for understanding regular and irregular bearing phenomenon in mango.
- Identification of specific gibberellins responsible for antagonistic effects on floral initiation in mango.
- Root dynamics in relation to assimilate partitioning and transformation and temporal relationships with crop phenolgy in mango.
- Understanding the mechanism of host-pathogen interaction for effective disease management.

Natural resource management

- Development of organic farming modules for domestic and global markets.

- Development of integrated nutrient management (INM) practices for nutrient budgeting and targeted quality production.
- Development of effective and efficient water use management strategies in mandate crops.
- Microbial diversity, microbial association and their dynamics in fruit tree rhizosphere systems in relation to nutrient transformation, recycling, dynamics and soil health.
- Development of diagnostic kits for rapid diagnosis of micronutrient deficiencies in fruit crops.
- Developing leaf/tissue analysis, CND norms for different soils/crops/varieties/ geographical associations for diagnostics and advisory.
- Carbon sequestration potential in mango/guava based cropping systems and nutrient management practices.

Secondary agriculture

- Effective post-harvest handling and storage protocols for enhancing shelf life and reducing post-harvest losses.
- Development of value added, processed and fermented products from mango, guava, bael, aonla and other underutilized fruits.
- Identification of bio-active compounds for development of functional foods and health drinks.
- Utilization of fruit processing industry wastes for food, feed, fuel and fibres.

Inputs and energy management

- Development of tools and implements for pre- and post-harvest operations with focus on small farmer mechanization.

Biorisk management

- Development of forecasting models and decision support systems and their utilization in pests/diseases management.

- Survey, surveillance and development of cost effective eco-friendly management practices for newly emerged pests and diseases.
- Development of pesticides spray schedules having minimum pesticide residues.
- Development and popularization of cost effective IPM practices for increasing the productivity per unit area.

Policies

- Commercialization of the techniques/technologies developed.
- Genetic fingerprinting of germplasm and its registration including IPR issues.
- Registration of released varieties.
- Patenting of processes, products and technologies related to mandate fruits.
- Documentation of ITKs.

Transfer of technologies

- Constraint analysis and impact assessment of new technologies.
- Production of nucleus planting materials and their distribution.
- Large scale demonstration of proven technologies through KVKs and FLDs.

6. Epilogue

A reputed institute involved in the subtropical fruit crops research and development, CISH is committed to augment productivity of quality fruits for improving livelihood opportunities of farmers and for ensuring sustainable farming and contribute to inclusive agricultural growth. Though there are many challenges, the technology and innovations developed need to be collated and integrated into production systems for ensuring sustainability and profitability to the farmers. Development of trait-specific varieties, integration of pre-harvest practices with post-harvest management system, adoption of value chain concept, mechanization for small farmers, value addition, supply chain management, market intelligence, creation of alternate markets, ensuring food and environment safety will undoubtedly infuse dynamism into the prevailing scenario and render the subtropical horticulture avocation competitive. It is while expected that these commodities may have to compete for place in the emerging fruit basket, fruits like mango will continue to demand prime position. Great strides made in research need to be translated into effective action plan backed by conducive policy support in order to place this sector in envious position.

Annexure 1: Strategic framework

Focus of research	Critical issues to be addressed
• Management of genetic resources in mango, guava, aonla and bael and some underutilized fruits for crop improvement	• Safeguard of genetic resources, their enhancement and utilization. Use of biotechnological tools for crop improvement, genomics and gene function • Development of cultivars resistant to biotic and abiotic stresses, besides yield and quality
• Plant health management system	• Health management of seeds and planting materials
• Integrated water and nutrient management for improved productivity	• Enhancing the productivity of water and nutrients by appropriate understanding of its dynamics • Efficient utilization of resources and production system management for high profitability including the power of micro-organisms
• Development of disease diagnostics for anthracnose, powdery mildew in mango and *Fusarium* wilt in guava	• Gene specific marker identification for molecular diagnostics of guava wilt disease caused by *Fusarium oxysporum* f. sp. *psidii* • Molecular tools to assess the surveillance of anthracnose pathogen (*Colletotrichum gloeosporioides*) during latent period of disease • Molecular approaches for identification of powdery mildew pathogen (*Oidium mangiferae*)
• Mechanization for small farmers	• Mechanization for enhancing the efficiency of human capital
• Post-harvest management including value addition	• Post-harvest management, value addition and marketing

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agri search with a human touch